The Demand Side: Behavioral Patterns and Unpicked Low-Hanging Fruit

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GHG reduction opportunities widely distributed – 2030 mid-range case

Abatement costs <$50/ton

Cost

Real 2005 dollars per ton CO_2e

100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-230

Residential electronics

Residential buildings - Lighting

Fuel economy packages – Light trucks

Industrial process improve-ments

Coal mining – Methane mgmt

Nuclear new-build

Low-, mid-penetration onshore wind

Active forest management

Distributed solar PV

Commercial buildings – HVAC equipment efficiency

Residential buildings – HVAC equipment efficiency

0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2

Potential

Gigatons/year

Commercial electronics

Fuel economy packages – Cars

Commercial buildings – New shell improvements

Cellulosic biofuels

Industry – Combined heat and power

Conservation tillage

Manufac-turing – HFCs mgmt

Natural gas and petroleum systems mgmt

Afforestation of pastureland

Reforestation

Winter cover crops

Coal power plants – CCS new builds with EOR

Biomass power – Cofiring

Industry – CCS new builds on carbon-intensive processes

Coal-to-gas shift – dispatch of existing plants

Car hybridi-zation

Source: McKinsey & Co.

Decreased Energy Use

Halt SUV Sales

Gasoline Rationing

Overly Strict Building Standards

LED General Lighting (Now)

Plug-In Hybrids (Now)

Hybrid Gas-Electric Vehicles

LED General Lighting (Future)

Plug-In Hybrids (Future)

Appliance Efficiency Standards

"Smart" Regional Land Development

Optimized Building Construction

Old appliance replacement

Enterprise Mgmnt Software

Program Thermostat, Tire Pressure, Lights, Driving Patterns, TV Usage

Energy Audits (and followup)

LED: Traffic Lights, Task Lighting

Compact Fluorescent Penetration

Efficient AC-DC Converters

Pigouvian Energy Tax

"Smart Buildings" Controls

Reformed Fuel Efficiency Standards

Appliance Energy Labeling

Smart Meters and Feedback

Congestion Pricing

Reduced Cost

Some Rail Rapid Transit Systems

Much Incandescent Lighting

Gasoline Price Controls

Internet Growth

Economic development

High Definition TV

Personal Computer Penetration

Airline Deregulation

Accessible Business Travel

Increased commercial space

Enhanced Travel Infrastructure

Why Do Negative Cost Options Continue ?

Some Incomplete Explanations

Market Failures and Behavioral Issues

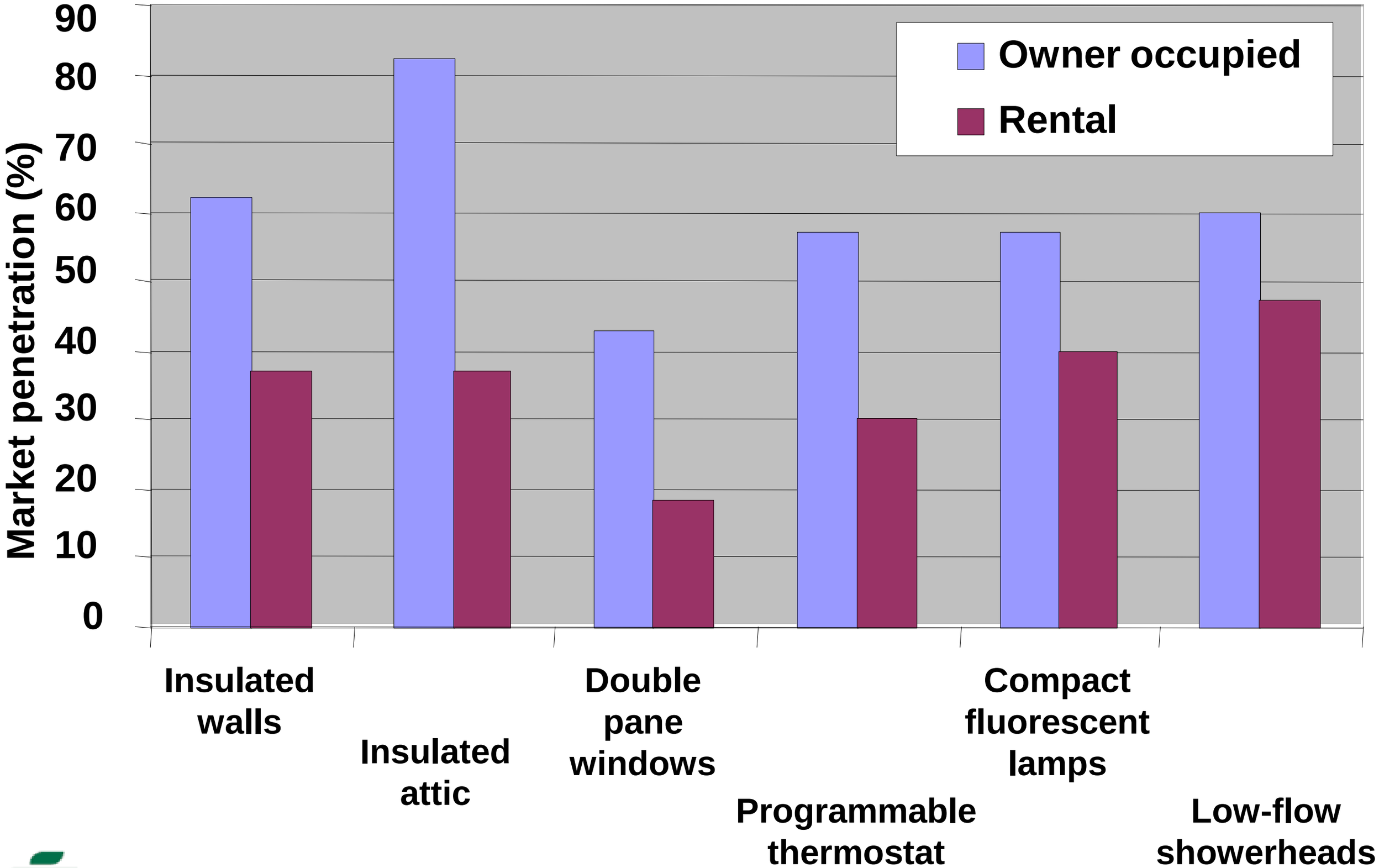
Market failures	Behavioral Issues
Externalities: Usage; R&D	Low salience of energy issues ???
Principal/Agent Problems	Principal/Agent Problems
Poor Information about Prices and Energy Use	Poor Information about Prices and Energy Use
Incomplete markets for energy efficiency	Managerial Priorities
Systems Issues (E.g. Chicken & Egg)	Lack of Energy-Related Information Systems
Distortionary regulatory and fiscal policies	Cognitive Skills

Principal/Agent Problems

- **Examples**
  - **New Building Construction**
  - **Rental vs Owner-occupied buildings**
  - **Consumer Product Design**
  - **Consumer Product Marketing**

- **Information/cognitive limitations generally central to agency problems**
  - **Electricity Use by TVs, passive chargers**
  - **Digital set top recorders**

Market Penetration of Energy Efficiency Measures in Owner-Occupied and Rental Housing in California (CEC 2004)



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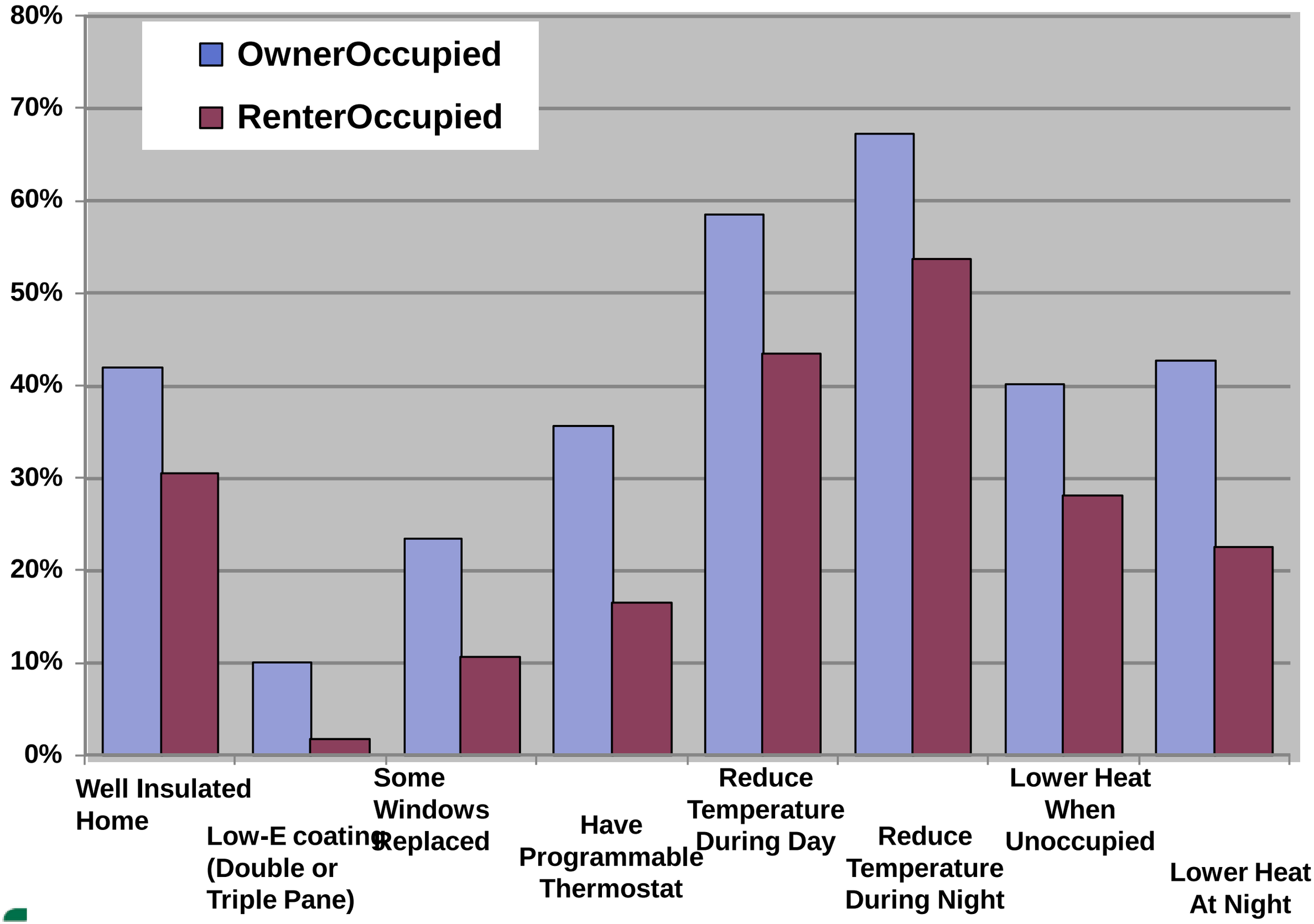
Fraction of Homes With Efficient Technologies or Behaviors

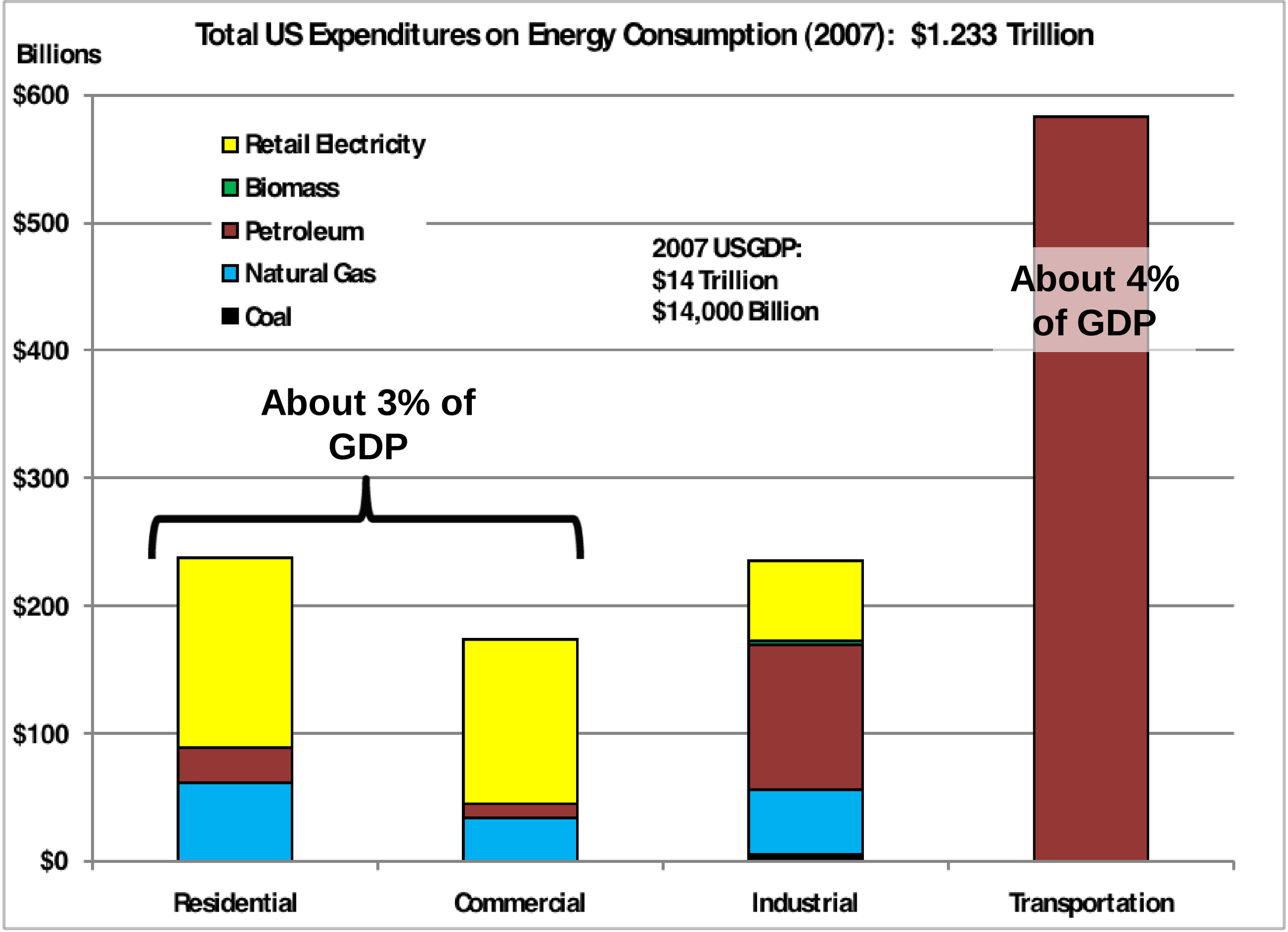


Source: Calculated from the 2005 RECS survey, by Anant Sudarshan

Behavioral Issues: Salience/Cognitive

- **Low Priority of Energy Issues**
  - **Often stated: energy costs are so small that it is not worth the effort to try to optimize.**
    - **Transactions costs of optimizing are greater than marginal gain.**
  - **But I doubt that is end of story.**

- **Cognitive issues**
  - **Probably very important for residential, small commercial, and individual transportation decisions**
  - **2004 study. Only 20% of Americans own programmable thermostats. Of those, 70% have never programmed their thermostats.**



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Electricity includes non-primary energy costs of electric system

Poor Information: Prices and Energy Use

- **Electricity Use: Point of Purchase**
  - **Ease of Information about use (TV, Communications Equip.)**
    - **When appliance is on**
    - **When appliance is off**
  - **Appliances purchased in emergency**
    - **Water heaters**
    - **Furnaces**
  - **This problem need not be: e.g. refrigerator cost labeling**

- **Electricity Use By Appliances: Time of Use**
  - **Monthly electricity bills**
    - **What is link between what you do and the monthly bill?**
    - **What is the price structure you face for electricity?**

How To Deal With Problems?

- There is not just one problem
  - Therefore there is not going to be a single solution
- Can we match solutions to the particular problems?

- One Solution: Go beyond the economics

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"It runs on its conventional gasoline-powered engine until it senses guilt, at which point it switches over to battery power."

Some Motivational Approaches

- **Pricing**
  - **A carbon price would have pervasive effects on energy use in all sectors**
  - **However, carbon prices will not address many of the market failures nor the information and cognitive issues**
  - **Navy experiment with base housing: benchmarks and charges or payments for deviations in energy use from the benchmarks**
  - **Gasoline taxes in Europe vs US motivate purchase of smaller more fuel efficient vehicles**

Some Motivational Approaches

- **Information**
  - **Labeling; e.g. Energy Star**
  - **Building performance rating and rating disclosure.**
    - **E.g., California mandatory building ratings**
  - **Easily processed economic data**
- **Information systems**
  - **New genre of enterprise-wide energy and carbon accounting and management software.**
  - **E.g., C3, Hara. Make it less costly to find energy efficiency options in large distributed organization, allow central management of energy and carbon savings, allow alignment of incentives with management energy goals**

Other Motivational Approaches

- **Feedback (immediate information linked to decisions)**
  - **Smart meters, sensors, energy information appliances**
  - **Google/Stanford experiment with Google Powermeter**
  - **Three levels of possible feedback**
    - **Consumer use of appliance/technology**
    - **Consumer purchase of appliance/technology**
    - **Manufacturer supply of appliance technology**

Other Motivational Approaches

- **Stochastic Rewards**
  - **Balaji Prabhakar congestion experiment with Infosys in Bangalore, India**
  - **Goal: incentives for Infosys commuters to travel at uncongested times**
  - **Infosys employees given chance for one month extra salary each time they took bus to arrive one half hour earlier than rush hour, two chances for arriving one hour earlier.**
  - **Expected value per ticket was 20 rupees – 10 cents.**
  - **Roughly 15% of employees decided to come one-half hour or one hour early.**

Other Motivational Approaches

- **Social norms**
  - **Billing information that compares electricity use to neighbors or other norms. E.g. OPower mailings.**
  - **Navy housing experiments mentioned in last slide**

Analogies

- **Smoking. How did US move from nation of predominantly smokers to predominantly non-smokers?**
- **Motivating obesity solutions**
  - **If most of your friends are obese, then obesity is seen as norm**
- **Motivating litter reduction**
  - **Robert Cialdini work**

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